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Proxy comparisons for Paleogene sea water temperature reconstructions

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Several studies have reconstructed Paleogene seawater temperatures, using single- or multi-proxy approaches (e.g. Hollis *et al.*, 2012 and references therein), particularly comparing TEX_{86} with foraminiferal $\delta^{18}O$ and Mg/Ca. Whereas trends often agree relatively well, absolute temperatures can differ significantly between proxies, possibly because they are often applied to (extreme) climate events/transitions (e.g. Sluijs *et al.*, 2011), where certain assumptions underlying the temperature proxies may not hold true. A more general long-term multi-proxy temperature reconstruction, is therefore necessary to validate the different proxies and underlying presumed boundary conditions.

Here we apply a multi-proxy approach using foraminiferal calcite and organic proxies to generate a low-resolution, long term (80 Myr) paleotemperature record for the Bass River core (New Jersey, North Atlantic). Oxygen ($\delta^{18}O$), clumped isotopes (Δ_{47}) and Mg/Ca of benthic foraminifera, as well as the organic proxies MBT'-CBT, TEX_{86}^{H}, $U_{37}^{K'}$ index and the LDI were determined on the same sediments. The youngest samples of Miocene age are characterized by a high BIT index (>0.8) and fractional abundance of the C_{32} 1,15-diol (>0.6; de Bar *et al.*, 2016) and the absence of foraminifera, all suggesting high continental input and shallow depths. The older sediment layers (~30 to 90 Ma) display BIT values and C_{32} 1,15-diol fractional abundances <0.3, implying marine conditions.

The temperature records (~30 to 90 Ma) show the global transition from the Cretaceous to Eocene greenhouse world into the icehouse climate. The TEX_{86}^{H} sea surface temperature (SST) record shows a gradual cooling over time of ~35 to 20 °C, whereas the $\delta^{18}O$-derived bottom water temperatures (BWTs) decrease from ~20 to 10 °C, and the Mg/Ca and Δ_{47}-derived BWTs decrease from ~25 to 15 °C. The absolute temperature difference between the $\delta^{18}O$ and Δ_{47}, might be explained by local variations in seawater $\delta^{18}O$ composition. Similarly, the difference in Mg/Ca- and $\delta^{18}O$-derived BWTs is likely caused by uncertainties in the seawater Mg/Ca model and the relationship between the seawater Mg/Ca and the incorporation of Mg into the foraminiferal shell. The $U_{37}^{K'}$ index could not be calculated as only di-unsaturated alkenones were identified, indicating that SSTs were > 28 °C. In contrast, LDI temperatures were considerably lower and varied only between 21 and 19 °C. MBT'-CBT derived mean annual temperatures for the ages of 9 and 20 Ma align well with the TEX_{86}^{H} SSTs. Overall, the agreement of the paleotemperature proxies in terms of main tendencies, and the covariation with the global benthic oxygen isotope compilation suggests that temperatures in this region varied in concert with global climate variability. The fact that offsets between the different proxies used here remain fairly constant down to 90 Ma ago, indicates that the fundamental mechanisms responsible for the proxy relation to temperature remained constant.

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